10/502070
DT12 Rec'd PCT/PTO 20 JUL 2004

SPECIFICATION

TITLE

# "HEAT SOURCE OR HEAT SINK SYSTEM WITH THERMAL GROUND COUPLING"

## BACKGROUND OF THE INVENTION

The present invention relates to a heat source or heat sink system with thermal ground coupling for near-surface recovery of thermal energy from the ground or for near-surface discharge of thermal energy into the ground, wherein the system comprises at least one ground probe arranged in the ground, wherein thermal energy can either be withdrawn from or discharged into the ground by means of a heat transfer fluid supplied through the ground probe, wherein each ground probe comprises a metallic probe shaft that is tight against the surrounding ground and consists of several drive-pipe segments driven into the ground, and wherein either an immersion pipe that is open at its lower end or a U-shaped pipe loop is arranged in the probe shaft for supplying or removing the heat transfer fluid.

Systems for the aforementioned types of intended use are known from practice in various executive forms. In essence, these known solutions can be grouped in three different groups.

A first group of systems according to the known state-of-the-art is operated with an open circuit, wherein groundwater is collected from a groundwater conduit, is cooled or heated in a heat pump or another unit and is returned to the groundwater conduit. However, this heat recovery from or heat discharge into the groundwater is possible only if an appropriate groundwater conduit is available and if the quality of the groundwater is satisfactory. In addition, the collection and return of groundwater requires official approval which is granted only under specific conditions.

Furthermore, panel collectors are already known, which are usually designed as horizontally arranged tube-register heat exchangers and are placed in the ground at a depth of approximately 1 m or slightly more. Such panel collectors require extensive earthworks, thus causing expensive installation; in addition, they can often not be used owing to local conditions.

Finally, ground probes are known for the establishment of heat source systems. These known ground probes consist of a single or double pipe loop installed in a borehole that is drilled vertically into the ground. In general, the depth of the borehole is less than 100 m, but it may also exceed this value. Where sandy soil is concerned, the boreholes are usually drilled according to flush drilling method. In solid ground, use is mostly made of what is called the airlift drilling method with an in-hole hammer. This drilling method requires provision of a two-stage air compressor with a working pressure ranging up to 24 bar and an operating energy input of 200 kW and higher. Where unconsolidated rock is concerned, a protective piping is used for drilling, said protective piping being, in practice, for example typically 152 mm in diameter. In hard rock, a typical diameter of, for example, 128 mm is used for continuing the drilling process until the particular final depth required is reached. The pipe loop assembly must be inserted in the finished ground borehole. Thereafter, the remaining space between the pipe loop and the walls of the ground borehole must be progressively filled with filling material from bottom to top, said filling material in practice mostly being bentonite, i.e. a cement-clay mixture. This ensures that water-bearing layers are reliably and permanently sealed against each other and that the thermal contact required between the pipe loop and the ground is ensured. It is also obvious that the establishment of such a system is very complicated and, thus, expensive. In addition, such systems require official approval, so that additional cost and time expenditures are caused by the appropriate application for and processing of the approvals. What is more and as practical observations have shown, the responsible authorities often treat such applications in a restrictive manner and with exaggerated care as regards the potential contamination of groundwater in case of leakages.

An apparatus for inserting rod-type heat exchangers into the ground is known from DE 79 36 659 U1. It is, preferably, provided that the heat exchangers used therein have the form of drive core probes that are composed of segments screwed to each other by means of tapered threaded parts. This is to disadvantage in that the screwed connections between the segments are sensitive while the driving-in procedure is in progress, and have a tendency to tears and leaks associated therewith; this also applies to the welded or soldered connections that are known from practice. The cutting of threads, the welding or the soldering are to disadvantage in that all of these processes result in local changes in the structure and hardness of the material of the probe shaft segments and, thus, in potential weak spots which may, sooner or later, be the starting point of cracks or breakages.

For that reason, the present invention aims at creating a system of the aforementioned type which obviates the drawbacks disclosed and which can, in particular, be established in an economical manner, which is particularly safe with regard to potential environmental impairments, which has a long service life, and which has a first-rate efficiency.

## SUMMARY OF THE INVENTION

This problem is solved by the invention by means of a system of the aforementioned type that is characterized in that each drive-pipe segment [consists] is made of ductile cast iron, the drive-pipe segments are formed such that they can be fitted into each other at their ends, and each drive-pipe segment comprises a tapered outer perimeter at one of its ends and, at its other end, a sleeve provided with a stop shoulder and having a mating tapered inner perimeter, wherein their diameters and taper angles are dimensioned such that the drive-pipe segments, on being driven in, can be connected to each other in a force-closed and tight manner.

Initially, it is provided according to the invention that each drive-pipe segment [consists] is formed of ductile cast iron. In essence, ductile cast iron differs from traditional gray cast iron in that the graphite is contained in ductile cast iron in the form of nodular graphite, so that the mechanical properties are changing; in particular, the strength and tenacity are increased. As compared with gray cast iron, the chemical properties of ductile cast iron are also improved, in particular the corrosion resistance against pitting. The drive-pipe segments can, for example, be produced according to the centrifugal casting method, wherein it is practically possible to use 100-percent recycling material, i.e. steel scrap, this being both to economical and ecological advantage. Since they are subjected to a special post-casting process, the drive-pipe segments of ductile cast iron have such a mechanical resistance that they can be driven into the ground with considerable impact forces without suffering any damage. To further facilitate the formation of the probe shafts, the invention provides that the drive-pipe segments are designed such that they can be fitted into each other at their ends. Large-scale screwed, soldered or welded connections which can be established and tested on the construction site only under the greatest difficulties are not required between the successive drive-pipe segments. This also facilitates the mechanical treatment of the ends of the drive-pipe segments during their production and also reduces the amount of work and

the risk of faults on the construction site at the place where the drive-pipe segments are driven into the ground. Therein, it is, furthermore, provided according to the invention that each drive-pipe segment comprises a tapered outer perimeter at one of its ends and, at its other end, a sleeve having a mating tapered inner perimeter, wherein their taper angles are dimensioned such that the drive-pipe segments, solely by being driven in, can be connected to each other in a force-closed and tight manner. This embodiment of the drive-pipe segments ensures that the desired tightness and force-closed connection of the various drive-pipe segments to each other is obtained solely by the drive-in process. Special sealants are not required. Each sleeve is provided with a shoulder and, as regards the fitted part of the respectively other segment, is designed such that, after the sleeve has been expanded by a defined amount, the fitted segment comes to rest on this shoulder and then transfers the drive pulses, therein preventing the sleeve from being subjected to the stress of a further expansion to an impermissible extent. If the pulses or drive blows for driving in the drive-pipe segments are sufficiently strong, a friction weld ensuring the desired tightness and force-locking connection for very long operating times of the probe shaft is obtained in the region where two drive-pipe segments are connected to each other. Since it is not necessary to ensure that the individual drive-pipe segments are, at a later point, disconnected from each other without being destroyed, this non-detachable friction-welded connection is not of any technical disadvantage whatsoever.

Since the probe shafts each [consist of] comprise several drive-pipe segments driven into the ground, a particularly economical establishment of the system is ensured. This high economical efficiency is, in particular, achieved because the time and technical expenditures required for driving in the drive-pipe segments in order to form the probe shaft by means of appropriate devices, particularly by means of a commercially available hydraulic hammer, are less than those required for establishing a ground borehole; this applies, in particular, to energy expenditures which are reduced by at least 80 percent. As a matter of course, the drive-pipe segments are designed such that, when being driven into the ground, they can absorb the impact forces developing without suffering any damage. The probe shaft is to advantage in that it is tight against the surrounding ground solely by being driven in, so that the heat transfer fluid is practically prevented from being flowing out of the probe shaft and into the ground, and this the more so since the drive-pipe segments forming the probe shaft have relatively thick walls because of the mechanical stability required. Therein, the tightness

is maintained according to the life expectancy of the probe shafts, even over long periods of many decades.

The system according to the invention permits to achieve a high efficiency because each probe shaft, after having been driven into the ground, is in a firm and close contact with the surrounding ground without special filling or contact materials having to be placed into the region of the outer perimeter of the probe shaft. This ensures a first-rate heat transfer from the ground into the probe shaft and vice versa, without particular measures being necessary. Since the probe shaft itself is metallic, its thermal conductivity is very high so that the resistance to the heat conduction out of the ground and into the heat transfer fluid flowing in the inner region of the probe shaft and vice versa is, altogether, very low.

The system can be used both as a heat source for heating purposes and as a heat sink for cooling purposes. Therein, the system can, for cooling purposes, be used either at the natural temperature level or with interconnection of a reversely operated heat pump, i.e. a refrigeration unit. If a reversible heat pump is used, it is even possible to optionally and alternately select the heating or cooling mode. This application is to particular advantage, especially in southern hot climates of the earth or in regions with typical continental climate.

In a further embodiment, the invention preferably proposes that the tapered outer perimeter of each drive-pipe segment is provided at the latter's forward end and that the sleeve with the stop shoulder of each drive-pipe segment is provided at the latter's backward end. This embodiment permits to achieve as low a motional resistance of the drive-pipe segments as possible when they are driven into the ground.

A further contribution to a high economical efficiency is obtained by the fact that only an immersion pipe that is open at its lower end is required for supplying and removing the heat transfer fluid, wherein, preferably, the outer diameter of the immersion pipe is, furthermore, smaller than the inner diameter of the probe shaft and the length is slightly smaller than the length of the probe shaft. The second half of the flow path of the heat transfer fluid then extends through that part of the interior region of the probe shaft that is not occupied by the immersion pipe. This construction results in a very low hydraulic resistance of the ground probe, this being of decisive importance in practice. Herein, it is not necessary to place a filling material.

As an alternative, a U-shaped pipe loop is arranged in the probe shaft in the stead of the immersion pipe for supplying and removing the heat transfer fluid, wherein it is,

furthermore, preferably provided that the length of said pipe loop extending up to the latter's U-bend is slightly smaller than the length of the probe shaft and that the part of the interior region of the probe shaft that is not occupied by the pipe loop is filled with a thermally conductive filling material. This embodiment of the system according to the invention provides the advantage of a particularly high protection against an ingress of the heat transfer fluid into the ground in the environment of the probe shaft since, here, both the pipe loop and the probe shaft must become leaky before the heat transfer fluid can penetrate into the ground. On the other hand, this increased safety results in a slightly lower efficiency because, here, the resistances to the heat conduction from the ground into the heat transfer fluid and vice versa are, altogether, slightly higher.

In order to achieve as great an advance as possible with as low driving forces as possible when the drive-pipe segments are driven into the ground, the first advancing drive-pipe segment of the probe shaft is, at its forward end, appropriately provided with or tightly connected to a probe tip. If the probe tip is tightly connected to the drive-pipe segment, this connection is appropriately established in the manner described above by tapered connection regions and their being friction-welded by drive impacts.

It is, furthermore, provided according to the invention that the last drive-pipe segment of the probe shaft is, at its backward end, tightly connected to a connection cover attached after completion of the drive-in procedure, with an inflow line connection and a return flow line connection for the heat transfer fluid being arranged on said connection cover. The connection cover provides the necessary connections for the inflow and the return flow of the heat transfer fluid. Since it is to be placed subsequently, the cover does not disturb when the drive-pipe segments are driven in. Since, as a result, the cover does not have to absorb any drive forces, it can be of a light-weight design, and the usual connection methods are appropriate for attaching the cover to the last drive-pipe segment and for sealing the cover. In a heat recovery system, it will be to advantage if the inflow of the heat transfer fluid is passed through the immersion pipe. The exit of the fluid out of the ground probe will then be achieved through the cover where the fluid, with regard to its temperature, has already reliably exceeded the frost limit, so that a splitting effect caused by the formation of ice, a problem that is known from refrigeration engineering, is prevented on the cover.

The fact that the immersion pipe or the pipe loop is mounted only to or in the connection cover further contributes to advantageously low production efforts. Expensive and

only difficultly accessible mounting means in the course of the probe shaft itself are not necessary here. Whether the immersion pipe or the pipe loop is exactly centered while extending through the probe shaft or whether it approaches the walls of the probe shaft to a higher or lesser degree is not of any noticeable importance either. Since the immersion pipe or the pipe loop is mounted to or in the connection cover, it is not yet positioned in the drive-pipe segments when these are driven in, so that neither the immersion pipe nor the pipe loop is disturbing or can be damaged in this step either. The immersion pipe or the pipe loop is inserted in the probe shaft only after the latter has been driven into the ground over the complete length provided.

In order to prevent the heat transfer through the ground probe and the remaining parts of the system from being disturbed by air bubbles, it is provided that the immersion pipe or the pipe loop comprises an air vent or a vent valve at its upper end. The air vent or vent valve permits air to exit out of the immersion pipe or the pipe loop at the uppermost point of the probe shaft and to be removed with the returning heat transfer fluid. Thereafter, the air is, appropriately, finally separated in the known manner by means of an automatic ventilation device in the highest part of the system.

Preferably, the immersion pipe or the pipe loop consists of plastic material, preferably of polyethylene (PE) or polypropylene (PP). In this manner, the material itself allows to achieve a first-rate thermal insulation value which keeps any undesired heat exchange between the inflowing and the returning heat transfer fluid inside the probe shaft at a very low level. In this manner, the immersion pipe is also relatively light so that it practically does not cause any tensile forces to the connection cover in connection with its buoyant lift in the heat transfer fluid. In order to further reduce the thermal short-circuit between the inflow and the return flow that is anyhow low, the immersion pipe can be provided with an additional insulation, for example in the form of a mounted corrugated plastic pipe, wherein the intermediate space between the immersion pipe and the corrugated pipe is, appropriately, also filled with the fluid.

According to the invention, it is furthermore provided that the probe shaft is driven into the ground either in vertical direction or in an inclined direction preferably extending at an angle ranging from 15 to 75 degrees in relation to the vertical direction. The particular drive-in direction depends on local conditions. If the surface area available is adequate, an inclined drive-in direction should be preferred because this permits to achieve a greater heat

collection area on the surface of the earth. In this manner, the amount of thermal energy required, for example for heating a residential building, can be obtained from the ground with a lesser number of probe shafts. As has already been mentioned above, the present invention relates, among others, to a system for near-surface recovery of geothermal energy, wherein this geothermal energy is generated by incoming solar radiation. For that reason, it is to advantage if the probe shaft extends at an inclined angle in relation to the vertical direction because, in this case, the area of the collection of the ground probe that is projected on the surface of the earth becomes greater than when the probe shaft only extends in vertical direction. An inclined course of the probe shaft or of an arrangement of probe shafts can be achieved by means of the drive-in method without any problems and, in particular, much more easier than the drilling of inclined boreholes, in particular if the angle in relation to the vertical direction is relatively large, for example more than 45 degrees.

If the ground is so solid that driving-in of the drive-pipe segments is difficult, it can, exceptionally, be provided that the probe shaft is driven into a borehole that has been predrilled into the ground, with the maximum depth of the borehole being as great as the length of the probe shaft and with the diameter of the borehole being smaller than the outer diameter of the probe shaft, this ensuring that the first-rate heat conduction contact between the ground and the probe shaft is achieved here as well. At the same time, driving-in is facilitated to an essential degree.

To ensure that the individual drive-pipe segments of the probe shaft can be driven into the ground without suffering any damage and to achieve the stability required to this end, it is preferably provided that the wall thickness of each drive-pipe segment, with the exception of the region at either of its ends, ranges from 10 to 20 percent of the outer diameter of the drive-pipe segment. Hence, the walls of the drive-pipe segments are very thick in relation to their diameter; but, owing to the high thermal conductivity of the metal used to make the drive-pipe segments, this is not to disadvantage to the heat transfer from the ground into the heat transfer fluid in the inner region of the probe shaft or vice versa.

In a more concrete embodiment that is well suitable for most of the applications occurring in practice, each drive-pipe segment, with the exception of the region at either of its ends, comprises an outer diameter approximately ranging from 80 to 200 mm and a wall thickness approximately ranging from 7 to 12 mm. If having the dimensions specified, the drive-pipe segments can still be driven into the ground with relatively low efforts and, thus,

with accordingly relatively light-weight machines, so that such drive-pipe segments can be driven into the ground without any problems, even in built-up areas, without causing any risk to buildings in the environment.

In a concrete embodiment, it is, furthermore, preferably provided that the length of each drive-pipe segment approximately ranges from 4 to 6 m and is preferably 5 m, and that the total length of the probe shaft approximately ranges from 10 to 50 m and even more if this is permitted by actual ground conditions. If having these dimensions, the individual drive-pipe segments can still be handled by two workers and the current handling devices, this facilitating the work on site at the place where the drive-pipe segments are to be driven into the ground. Only two persons, that is an operator for an excavator with a hydraulic hammer and a person to hand over the pipe segments and to assist in fitting the particular new pipe segment, are required as personnel. If the preferred total length of the probe shaft is as specified, it can, in practice, be expected in most of the cases that the drive-pipe segments of the probe shaft can still be driven in without any problems and at a relatively high drive speed. As has already been described above, driving-in of the drive-pipe segments is usually facilitated by the drive-pipe segments being inserted in the ground not vertically, but at an inclined angle.

For ecological reasons, the preferable heat transfer fluid is pure water, in particular without any antifreeze additive and in particular under a pressure of an order of approximately 10 bar. As a matter of principle, this excludes all groundwater and other environmental hazards; that is the reason why it is much easier to obtain official approvals and why these may even not be applicable at all.

As an alternative, the heat transfer fluid may also be carbon dioxide, in particular under a pressure of an order of approximately 100 bar and more. This permits operation of ground probes according to what is called the "heat-pipe" methods, the more so since the probe shafts, owing to their construction, are able to resist such a high internal pressure without suffering any damage. Moreover, an appropriately pressure-tight cover can, without any difficulties, be provided at, in particular welded to, the upper end of the probe shafts. It is also possible to optimize the "heat-pipe" method by selecting a favorable drive angle of the probe shaft and to distinctly improve said method as compared with the presently usual vertical boreholes.

As mentioned above, the ductile cast iron preferably used to make the drive-pipe segments is corrosion-resistant to an essentially higher degree than the usual gray cast iron. In order to protect the probe shaft even more against leaks, even in case of long operating times of several decades, each drive-pipe segment can, in addition, be provided with an anticorrosive layer on its external and/or internal surface. If saline water is present in the ground, for example near coasts, the probe shaft can be effectively protected against corrosion by means of an impressed current anode.

The anticorrosion layer can, for example, be formed by galvanizing or by a plastic coating, preferably of polyurethane (PU), wherein the material used should be oxygen-diffusion-tight.

A further contribution to avoiding corrosion damages consists in using pipes for the piping of the remaining system and for its connection with a heating or cooling device, which are oxygen-diffusion-tight. By this, an introduction of oxygen into the heat transfer fluid, which might promote corrosion of the drive-pipe segments, is prevented.

## BRIEF DESCRIPTION OF THE DRAWING

Executive examples of the invention will be illustrated below by means of a drawing, in which:

FIG. 1 is a schematic vertical sectional view of a heat recovery system with a single probe shaft in a condition where it is driven into the ground in vertical direction;

FIG. 2 is a longitudinal sectional view of a section of a modified probe shaft; and

FIG. 3 is a schematic vertical sectional view of a heat recovery system with two probe shafts driven into the ground at an inclined angle.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

According to the executive example shown in FIG. 1, the ground probe 1 consists of a probe shaft 2 that is composed of several drive-pipe segments 20. To form the ground probe 1, the required number of drive-pipe segments 20 are initially driven successively into the ground 3 in a relatively small building pit 30 that has been prepared beforehand, for example by means of a hydraulic hammer mounted to an excavator arm or a carriage. At first, the drive-pipe segment 20 that is the bottommost in the drawing is provided with a probe tip 23 in order to ensure that said drive-pipe segments 20 can be driven into the ground 3 with as low a resistance as possible and as easily and quickly as possible. Herein, the probe tip 23 is tightly connected to the forward end 21 of the lower drive-pipe segment 20. As soon as the first drive-pipe segment 20 has been driven into the ground 3 almost completely, a second drive-pipe segment 20 is fitted; thereafter, the first and second drive-pipe segments 20 are further driven into the ground 3 together.

The drive blows executed by the hydraulic hammer cause the drive-pipe segments 20 to connect to each other and to the probe tip 23 in a force-closed and tight manner. To achieve this, the forward end 21 of each drive-pipe segment 20 is provided with a tapered outer perimeter 21'. The backward end of each drive-pipe segment 20 and the rear side of the probe tip 23 are each provided with a sleeve 22 with a mating tapered inner perimeter 22' or 23'. Therein, the taper angles of the outer perimeter 21' and the inner perimeter 22' or 23' are selected and coordinated with each other such that the desired force-closed and tight connection is achieved solely by the drive blows or drive pulses executed while the drive-pipe segments 20 are driven in, wherein these occurring blows or pulses generate a friction-welded connection in the connection area. At its lower part, each sleeve 22 is provided with a shoulder 22'' or 23'' and, in connection with the fitted forward end 21 of the particular other segment 20, is designed such that the fitted end 21 of the segment 20 comes to rest on this shoulder 22'' or 23'' after the sleeve 22 has been expanded by a defined amount and will then

transfer the drive pulses without subjecting the sleeve 22 to stress in expansion direction to an impermissible extent.

Preferably, the drive-pipe segments 20 and the probe tip 23 [consist] are formed of ductile cast iron which has a particularly high strength and tenacity so that it can absorb the drive blows without suffering any damage and facilitates the desired friction-welded connection in the connection areas of the drive-pipe segments 20 when the latter are driven in. Once the necessary total length of the probe shaft 2, in practice for example approximately ranging from 10 to 50 m, has been achieved, driving-in of the drive-pipe segments 20 is completed. A connection cover 24 is placed onto the upper end of the upper drive-pipe segment 20 in a sealing manner and is secured with at least one locking screw 24'. The connection cover 24 comprises one inflow line connection 25 and one return flow line connection 27 for a heat transfer fluid. In the simplest case, the heat transfer fluid is water to which an antifreeze agent, usually alcohol, is added as required. An immersion pipe 26 that is only mounted to the connection cover 24 and is, otherwise, extending freely through the hollow inner region 28 of the probe shaft 2 is connected to the inflow line connection 25. Therein, the length of this immersion pipe 26 is only slightly smaller than the length of the probe shaft 2.

When the ground probe 1 is operated as a part of a heating device, cold heat transfer fluid flows through the inflow line connection 25 into and through the immersion pipe 26, until it reaches the lower end region of the probe shaft 2. At the lower end 26' of the immersion pipe 26, the heat transfer fluid exits out of the immersion pipe 26 and is now flowing from bottom to top through that part of the interior region 28 of the probe shaft 2 that is not occupied by the immersion pipe 26. On its way along the wall of the probe shaft 2 from bottom to top, the heat transfer fluid absorbs thermal energy from the surrounding ground 3, wherein the heat transfer fluid is heated as compared with its original temperature. The heated heat transfer fluid exits the probe shaft 2 through the return flow line connection 27 provided at the side of the connection cover 24. In the case of the heat recovery system assumed here, the return flow line connected to the connection 27 is usually running to a heat pump in which the geothermal energy contained and transported in the heat transfer fluid is withdrawn and is utilized for heating purposes, for example for building or water heating purposes. The heat transfer fluid which exits the heat pump and whose temperature is now reduced is then supplied back to the inflow line connection 25 and through the immersion pipe 26 into the

inner region 28 of the probe shaft 2. Hence, this system represents a closed heat-transfer-fluid circuit.

Intermittent operation of the associated heating device and heat pump is to particular advantage because the heat transfer fluid will, in this case, be able to absorb a relatively great amount of thermal energy from the ground while it is dwelling in the probe shaft 2, thus being subjected to a relatively great increase in temperature, this being favorable for the efficiency of the heat pump. Here, the high fluid content of the ground probe, which can, for example, be approximately 10 l/m in practice, becomes positively apparent. This results in typical times for a complete recirculation of the heat transfer fluid approximately ranging from 30 to 60 minutes.

Owing to its relatively great material thickness which it requires for being driven into the ground 3, the probe shaft 2 is absolutely tight over very long operating times ranging up to many decades, so that any exit of the heat transfer fluid out of the probe shaft 2 and into the ground 3 is practically excluded. After having been driven into the ground 3, the probe shaft 2 is closely embedded in said ground 3 so that, in connection with the first-rate thermal conductivity of the metallic wall of the probe shaft 2, a high efficiency is achieved on heat transfer from the ground 3 into the heat transfer fluid in the hollow inner region 28 of the probe shaft 2 and vice versa.

Appropriately, the inflow and return flow lines for the heat transfer fluid are also arranged in the ground 3, wherein an arrangement below the frost limit, e.g. at a depth of approximately 1 m or deeper if necessary, is to reasonable advantage.

According to FIG. 2, a pipe loop 29 that is positioned in the probe shaft 2 in U-shaped form can alternatively be used for routing the heat transfer fluid. Therein, the U-bend 29' is, appropriately, positioned near the lower end of the probe shaft 2. Herein, the heat transfer fluid remains enclosed in the pipe loop 29 along its entire path through the pipe shaft 2, being prevented from coming into an immediate contact with the probe shaft 2. For reasons of heat conduction, that part of the interior region 28 of the probe that is arranged around the pipe loop 29 is, therefore, filled with a thermally conducting filling material, for example water, which is then an essentially still fluid.

Depending on the energy requirements, a heat recovery system can comprise one or more probe shafts 2. If several probe shafts 2 or ground probes 1 are used, as is schematically represented in FIG. 3, said shafts or probes can be advantageously connected in series because of their low hydraulic resistance, wherein the length of the individual probe shafts 2 can be selected as desired. As a result, installation becomes markedly less expensive and a hydraulic calibration, which is always associated with energy losses, is not applicable. If necessary, however, it is, of course, also possible to connect a greater number of probe shafts 2 in parallel to each other or in a mixed arrangement.

In a system with several ground probes 1, the several ground probes 1 are spaced apart from each other depending on the collection area of each individual ground probe 1, wherein the size of the collection area depends on the thermal conductivity of the ground 3 in the particular case. It is also possible to drive the probe shafts 2 into the ground 3 at an inclined angle, as shown in FIG. 3, instead of vertically as shown in FIG. 1 of the drawing. This is to advantage in many application cases because, in this case, a larger collection area for the thermal energy irradiated by the sun across the surface of the earth and into the ground 3 can be achieved per probe shaft 2. With the direction of the probe increasingly deviating from the vertical direction, this will then allow an increasingly smaller probe spacing. With a specified amount of energy required, the upper ends of the probes 2 can then be arranged on a smaller total area, this saving space and installation cost.

As is apparent from the foregoing specification, the invention is susceptible of being embodied with various alterations and modifications which may differ particularly from those that have been described in the preceding specification and description. It should be understood that I wish to embody within the scope of the patent warranted hereon all such modifications as reasonably and properly come within the scope of my contribution to the art.